Cowtown Amateur Radio Club

Buildathon Project #5 – 2.5A Linear Power Supply

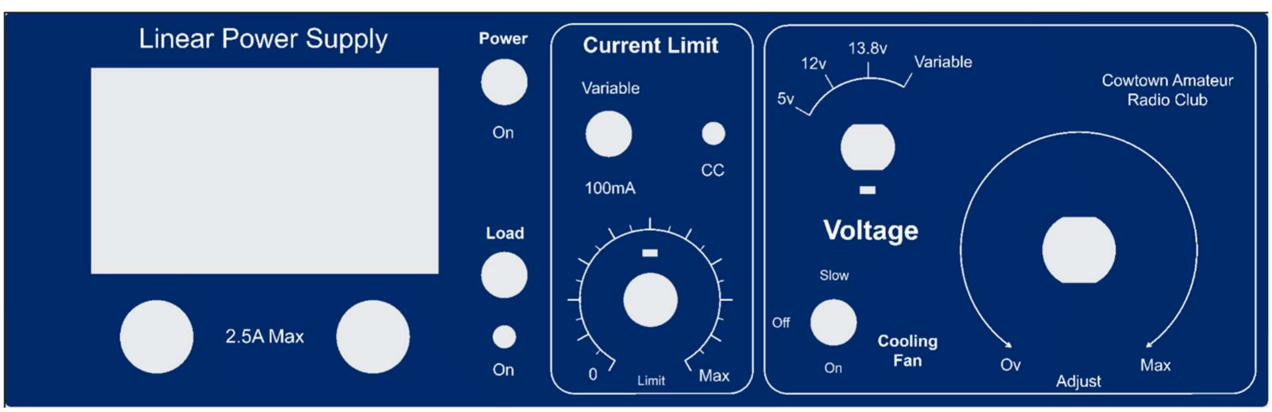
2.5A Linear Power Supply Construction Manual

By Richard Hinsley W5ARH / VK2ARH

Latest version of this manual can be downloaded from:

https://github.com/VK2ARH/Cowtown-Linear-Power-Supply-Project

Blue Front Panel Option shown below:



Version 1.1 12th July 2024 Initial Release

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Introduction

The 2.5A Linear Power Supply was chosen for the Club 2024 Buildathon as the fifth project in a series of projects to create interest and build practical skills amongst our members. The key components of the selection were:

- Low cost using readily available components.
- Use of through hole devices – to enable construction by novice/intermediate builders.
- Provide a practical piece of equipment that can be used in the shack or workbench to deliver a relatively 'noise free' DC power source for a variety of uses including QRP transceivers, receivers, general equipment or to provide a current limited supply for the work bench to protect circuits from overload should a short circuit be present during construction.
- The power supply provides both passive and fan cooling (high and slow speed operator selectable) based on the load and output voltage required.

- The power supply has the following characteristics:
  - Up to 2.5A continuous output#
  - Variable voltage from 0 – 30v *
  - Digital Ammeter and Voltmeter accurate to +/- 1%
  - Current limit function, either variable or 100mA fixed (operator configurable)
  - Variable or pre-selected fixed output voltages.
  - Cooling Fan On/Off/Slow switch to minimize cooling fan noise to load requirements.
  - Load Switch with LED – to connect and disconnect the power supply from the load.
  - Front and rear output terminals.
  - Fused AC input.

- dependent upon AC input voltage and DC Output Voltage
* - dependent upon AC input Voltage and DC current demand

The power supply requires an external AC input voltage in the range of 18-24v Max. For most amateur radio purposes, the selection of an 18v AC input source will be the best option to support output up to 13.8v. **The input voltage should NOT EXCEED 24v AC** otherwise you risk damaging the op-amps used for voltage and current control.

This project follows earlier projects which include the ADX and provides a suitable power supply for the ADX construction and operation. The power supply will also provide a practical solution to power requirements of future QRP radio builds and other construction projects, as well as general electronics projects.

The power supply utilizes a 0-30v DC power supply module which is readily available from a variety of sources and incorporates:

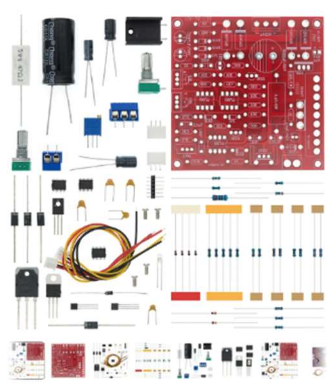
- A small number of modifications which are identified as part of the 'build'.
- The addition of external components and housing to provide flexibility in operation and a digital display for output voltage and current.
- Heatsink and Fans for cooling for the pass transistor, voltage regulator and some of the onboard components.
- The ability to select fixed outputs for constant current and preselected voltage control.
- Improved selectivity of the adjustable voltage control, and individual adjustment of the fixed voltage and current limit settings.
- An enclosure to protect the components together with a specially designed front panel and rear panel for the project.
- A custom PCB has been developed to simplify the wiring of the fixed voltage and constant current threshold circuitry, together with housing the fan speed and LED dimming resistors.
- This is a relatively easy kit to build as most of the work is associated with assembly and installation of components into the housing and the front and rear panels with a minimal amount of soldering – although some soldering and modification to the assembled power supply board is required.

Remember the Buildathon is designed to enable club members irrespective of experience or ability to come together and with guidance and support from others, enjoy a mutual learning and fun environment in which to build the projects and this power supply is no exception. The manual was written with a novice constructor in mind and is focused on a step-by-step instructional build process. Seasoned kit builders please ignore/excuse the verbosity and detail in parts.

I recommend that you read the manual cover to cover before commencing construction to gain an understanding of the process to be followed, the contents of this manual and familiarize yourself with the journey ahead.

There is a series of 5 videos available on YouTube by IMSAI Guy, which covers the theory of operation of each of the elements of this power supply board. I recommend anyone interested in understanding the theory of operation of this power supply view these videos and use them as an aid to fault finding should it be required or power supply improvements should they wish to do so. The first video in the series can be found here: https://www.youtube.com/watch?v=ndDZVUKL30E&t=79s

The basic power supply board supplied for this project includes both the pre-assembled board and the kit which contains the PCB and all the components used to build a pre-assembled board. The 'kit' components will be used to ease the process of modifying the pre-assembled board and provide a variety of spare components should they be required.



Step by Step Kit Assembly

Equipment Needed:

The following equipment is recommended to build the kit:

- Soldering Iron / Station (preferably ESD protected with a fine tip, together with a method of venting fumes away from the soldering area)
- Solder: 0.8mm diameter 63% Sn / 37% Pb with 'no clean' flux is recommended, if you are comfortable soldering with Pb based solder.
- Wire stripping tool suitable for 18AWG and 24AWG wire.
- Wire cutters (fine precision type) and long nose pliers
- Drill and 3mm (~1/8") drill bit.
- Multimeter
- Phillips head screwdriver, and small blade screwdriver (~2mm)
- Modeling knife
- Solder sucker or solder wick if needed.
- A magnifying glass or higher power reading glasses can assist with checking the quality of your soldering.

An external 18-24VAC power source is needed to operate this power supply – see later discussion in Step 8 p22.

The kit uses all through hole components.

Take the time to prepare your work area and layout your tools, keep it free of clutter. An organized work area helps you to focus on the build and not be distracted searching for tools and components.

An example of a cleared and ordered work bench ahead of the kit build. Individual equipment will vary.
(My workbench isn't always that tidy 😊)

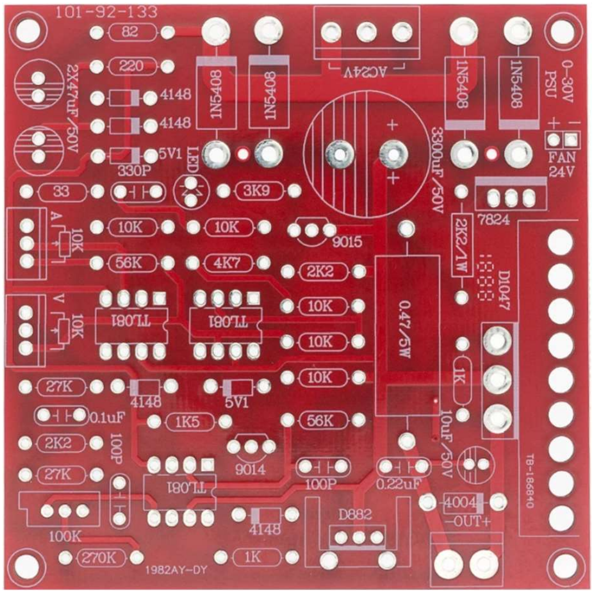
Bill of Materials (BOM)

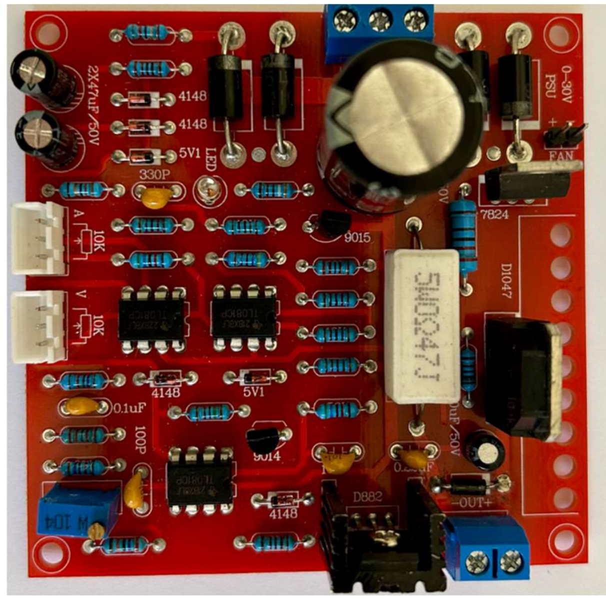
Description	Qty Per Kit	Comments
Power Supply Board - fully Assembled	1	
Power Supply Board - unassembled	1	To be used for spare parts or can be built for soldering practice and to provide for a second power supply project
Voltage Control PCB	1	
Printedf Front Panel	1	Either Blue or Back supplied as pre preference
Printed Rear Panel	1	Only Black supplied
Enclosure	1	
Heat Sink	1	Pre drilled - thanks to Dan Pate AI5OL
Larger Cooling Fan	1	For use with rear mounted heat sink
Small Internal Cooliing Fan	1	For cooling inside the enclosure
Cooling Fan Guard	1	For external heatsink fan
Small Knobs	2	For Current limit potentiometer and Voltage Selection
Large Knob	1	For Large Multi Turn Potentiometer
5812 Voltage Regulator	1	to replace onboard 7824
Large Multiturn Potentiometer 10K	1	Main Voltage Adjust
Multi turn Pot small (10K)	3	For Preset Voltage selection tuning
Multi turn Pot small (1K)	1	For Constant Current limit tuning
3mm Red LED	1	CC LED Display Optioni
3mm Green LED	1	Load ON LED Indicator
2P4T Rotary Switch	1	Fixed Voltage Selection Switch
Volt / Amp Display	1	
DPDT Mini Switch	2	Load and Current Limit switches
SPDT On - ON Mini Switch	1	Main Power Switch
DPTT ON-OFF-ON Mini Switch	1	Fan Control Switch
4mm Banana Sockets (Set - Red / Black)	2	Second set provided for optional rear panel output
5.5 x 2.1mm Socket	1	For AC Power Input
5.5 x 2.1mm DC Plug	1	For AC Power Input
Fuse Holder	1	For AC Power Input
3A 2x50mm Fuse	1	For AC Power Input
Solder Lugs	4	Connect on back of Banana Plugs for soldering connections
M3 Nyloc Nut	3	
M3 20mm Machine Screw	6	Mounting D1047, LM7812, Heatsing and PCB
M3 8mm Machine Screw	1	PCB 'Tie Down' to enclosure
M3 30mm Machine Screw	4	To secure fan / fan cover to the heatsink
M3 Spacer 6mm	3	PCB Standoff from Enclosure
M3 Washer	8	For use with M3 screws as required
M3 Split Washer	8	For use with M3 screws as required
M3 Nut	4	For use with M3 screws as required
9K1 Resistor	1	R1 on CC Circuit
120R 1/2W	1	R3 - Heatsink Slow Fan Speed Control
22R 1/2W	1	R4 - Internal Fan Slow Speed Control
1K2 1/4 W	2	LED Dimming (R2 and Load LED on Panel)
To-247 Silicon Insulator Sheets	2	7812 and D1047 transistor mounting
Plastic Transistor Insulator TO220	1	Mounting 7812
Male & Female Pin Headers 40 pin set	1	To assist with connections to the main PCB
Heat Shrink Tubing	Qty	
Hook Up Wire 18AWG and 24 AWG	Qty	3 color x 2' 24 AWG, Red/Black 2' 18 AWG Silicon Wire

Start by unpacking your kit, identifying each component, and checking the components against the BOM. Whilst every builder will have their own style and approach, identifying, sorting, and where appropriate labelling smaller components can save time during the build and minimize search effort and errors.

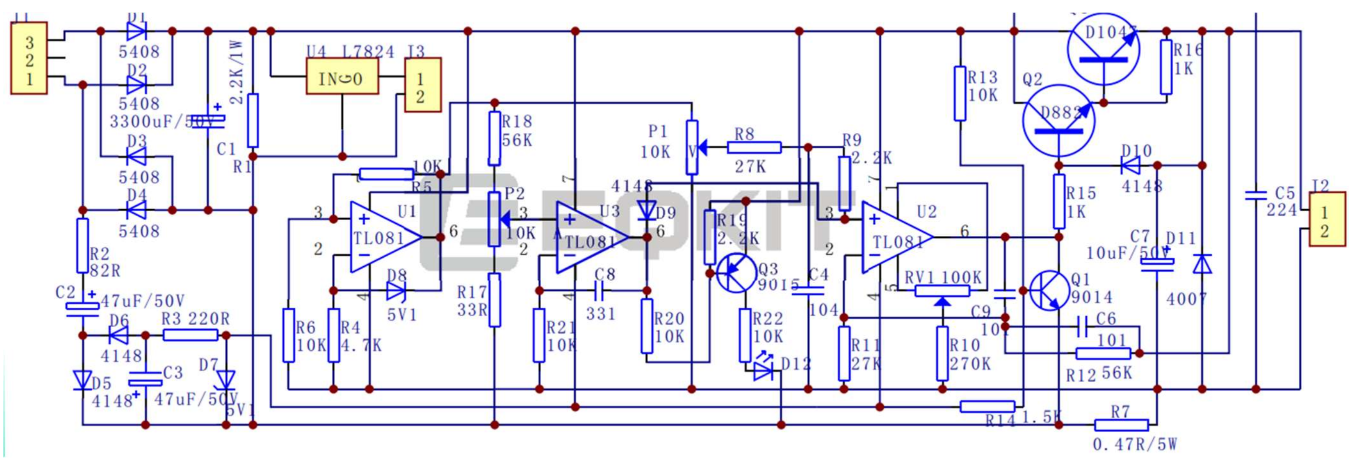
PCB and Schematic Diagram

Here is a layout of the component side of the main PCB, showing both the kit form and the pre-assembled version. Both the power supply kit (with all components) and the pre-assembled versions were supplied with the Cowtown Kit.





The full circuit schematic diagram for the main board courtesy of EEQKIT:



If you wish to build your own power supply main board from scratch using the supplied components – please be my guest. Instructions by EEQKIT to build the unassembled board have been reproduced at the end of this manual, although there may be slight differences between the EEQKIT and the board supplied, the silk screen printed on the supplied board will be sufficient to support construction.

This construction manual uses some of the components from the kit to augment the pre-assembled PCB to improve its operation.

Construction Tips

In this manual each time a component is to be identified and soldered to the PCB, it is listed separately proceeded with a square check box. You can 'tick' off the components as you progress, and this keeps a record of your progress through the build. You can also check off each page as you complete the activity listed on that page:

☑ Component or task 1
☑ Component 2 etc.

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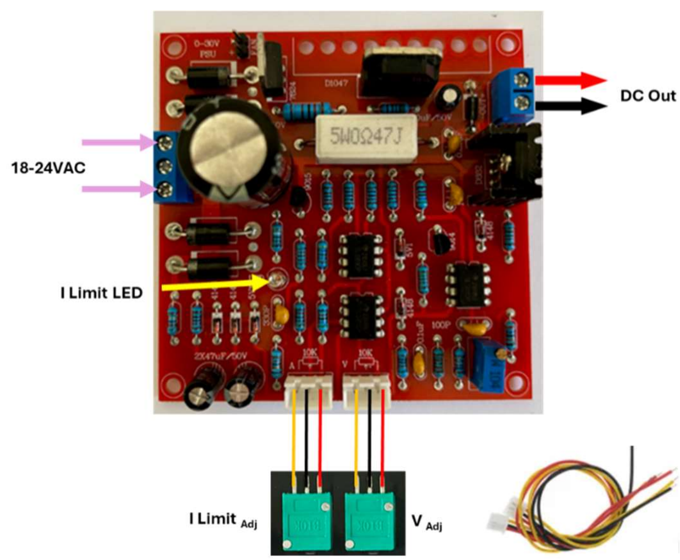
- Whilst the steps in this manual may appear daunting the wiring is logical and largely involves connecting external components mounted on the front and rear panels to the main PCB.
- Hookup wire can be obtained from a variety of sources – appropriate lengths of silicon wire are supplied with the Cowtown Kit, and this was chosen because soldering the wire after stripping does not result in the insulation layer melting. This wire is very flexible, which is both an advantage and disadvantage when wiring up the project.
- You can use various sources of wire from your 'junk box' as long as it meets the required current carrying capacity. Most hook up wire carries very little current (less than 200mA for the 12v supply and fan wiring) much less for voltage and current limit controls, so wire in the 24AWG – 28 AWG range should be good for this wiring. The main AC and DC supply lines will carry up to 3A so 18AWG wire is a safe choice.
- Having built a total of three prototype power supplies to get the final layout and design, I recommend that you follow the steps outlined in this manual to avoid rework or difficulty installing components.
- If you have access to a colour printer, printing out this manual and having it along side of you whilst constructing will be an aid, otherwise viewing the manual on an iPad or similar also works well during construction.
- Don't solder above the PCB when installing components or hookup wire – drops of solder may create short circuits on the PCB.

☐ **Test the main PCB before constructing your power supply.**

- I recommend testing the main PCB to ensure that it's working before we start the project. To do this:
    - Solder the 10K potentiometers to the 3 pin connectors supplied with the kit and connect them to the current limit and voltage control sockets.
    - Connect an 18-24VAC power source to the input terminals.
    - Measure the DC output voltage and observe the voltage varying whilst adjusting the V_{Adj} potentiometer. Do not connect any significant load to the supply at this stage as the D1047 pass transistor is not connected to a heat sink.
    - Rotate the I Limit adjust potentiometer and observe the voltage drop and LED illumination when at full rotation.



If all checks out you can use the board for the project with confidence.

Building the Power Supply in Stages

It is recommended that the power supply be built in stages using the following sequence:

1. Modifications to the main PCB
2. Build the voltage and current limit control board
3. Mount the main PCB in the enclosure
4. Assemble the components on the rear panel
5. Assemble the components onto the front panel including hook up wiring between the components
6. Wire up the front and rear panels to the main PCB
7. Fit the internal cooling fan
8. Prepare your external AC power supply
9. Test and Calibrate

Step 1: Modification to the Main PCB

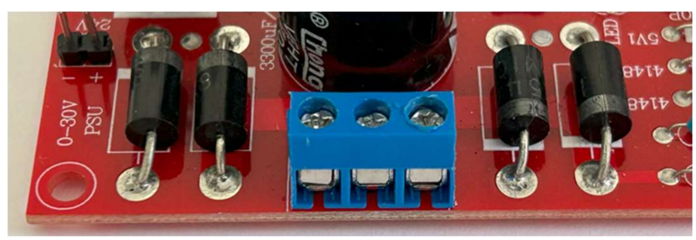
The modification to the main board is required to ensure:

- Greater protection of components during higher current load
- Connection of an appropriately sized heatsink for the voltage regulator and pass transistor
- Remote display of the current limit LED

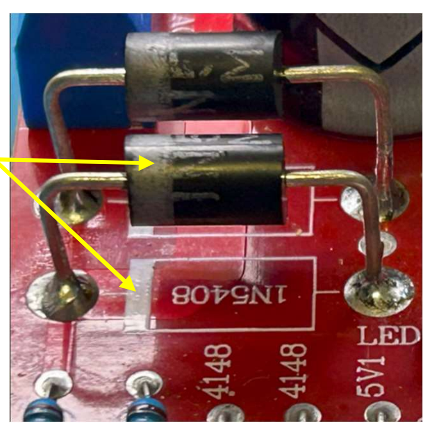
When operating with an output current greater than ~ 1A the temperature of the 1N5408 bridge rectified diodes (D1-D4) and the current sensing 5w 0.46R resistor become excessively hot – whilst within the rated capacity of these components, the heat generated has the potential to scorch the PCB and heat up adjacent components – for this reason it is recommended that these components are mounted 'proud' of the PCB to allow greater airflow around them.

☐ Modifying the 1N5408 Diode

Using a solder sucker or solder wick, remove the four 1N5408 diodes being careful not to damage the PCB pads. Once removed ensure that the holes are clear of solder (one technique is to melt the solder and insert a toothpick into the hole which prevents solder blocking the hold as it cools – solder suckers, solder wick etc. can also be used).

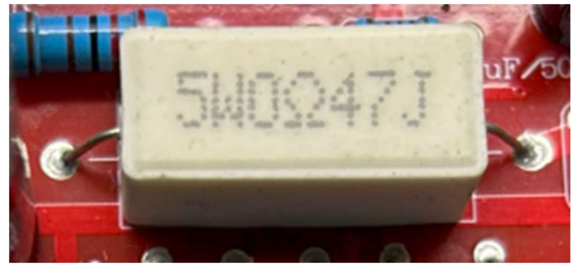


Replace the diodes with four new 1N5408's from the kit supplied, bending the diode leads in such a manner that when soldered onto the PCB they stand proud enabling air circulation. Remember to observe the correct polarization when installing the diode. The band on the diode should align with the band on the PCB.

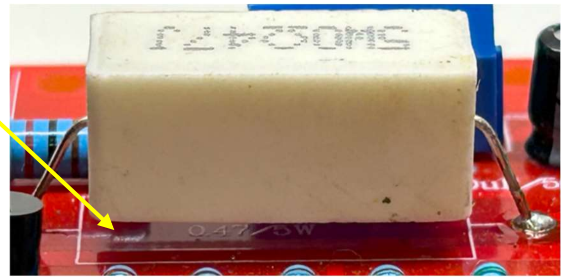


If you don't want to use the new 1N5408's it may be possible to achieve the same outcome by simply melting the solder joint and raising the component higher on the board depending upon how much lead was left during original manufacture. I have used both techniques successfully.

☐ Raising the Current Limiting 0.47R 5W Resistor



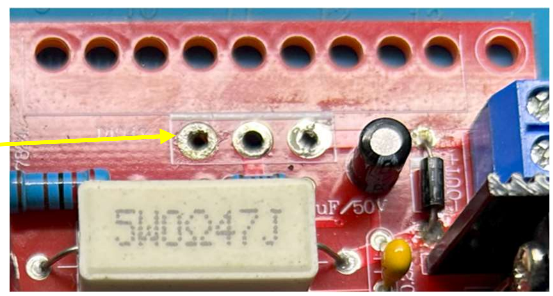
Using the same technique for the 1N5408 diodes remove and replace or raise the 0.47R 5W Resistor elevating the legs so that the resistor stands proud of the PCB to allow air circulation.



The resistor should now have an airgap beneath the resistor and the PCB. On the board I used the leads were long enough to simply melt the solder joint and lift the resistor higher on the board to create the air gap. If this is not the case with your board replace the resistor with a new one from the component kit.

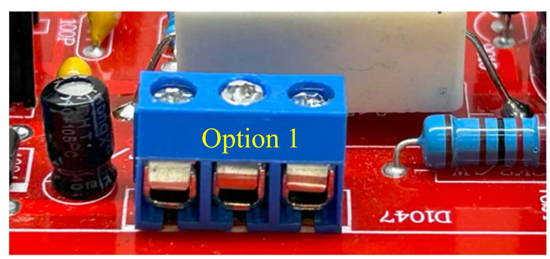
☐ Remove the D1047 pass transistor

The space allowed on the PCB does not allow for the installation of an appropriately sized heatsink so the main D1047 transistor (rated at 12A) and the 24v regulator needs to be removed from the board in order to mount them on a larger heatsink attached to rear panel. The 24v regulator will be replaced with a 7812 12v regulator to power the cooling fans and provide power to the digital display.

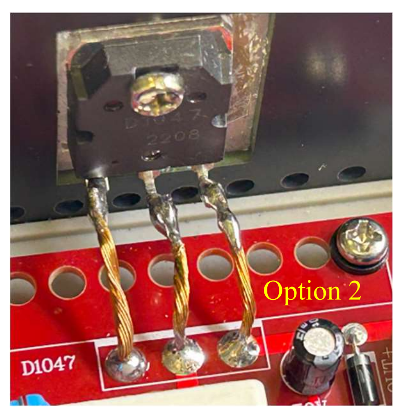


Start by carefully desoldering the D1047 transistor from the PCB.

This will present you with the first optional choice for your build. You can install a three-pin connector and use the screw connections to wire the pass transistor to the PCB (Option 1). Or you can solder three short lengths of 18AWG hookup wire or similar into these holes which are then soldered directly to the transistor on the heatsink (Option 2).



I initially chose Option 1 and used the three-pin screw connector provided in the component kit. This also gave me the option of easier replacement of the PCB or the pass transistor should something fail (although this has yet to happen) so this is an option.

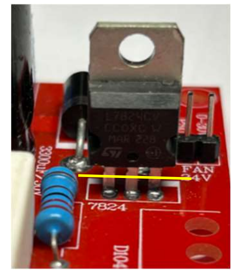


The screw connector is quite fiddly when attaching the connecting wires – so for the production version I found it easier to solder short leads directly to the PCB and solder them to the transistor. They are easy to unsolder from the transistor or board should replacement be required. No need to insulate them – they're not going anywhere.

I also found it easy to work with a small section (about 1.5" or 35mm long) of multistrand copper wire which was stripped from a section of mains wiring, twisted and then tinned, cut to length soldered directly to the PCB which was then soldered directly onto the shortened transistor leads after it was mounted on the heatsink. I would recommend this method.

At this stage choose which option you are going to use and mount the screw connector, or the wire fly leads to the transistor pads on the PCB.

☐ Remove the 7824 voltage regulator

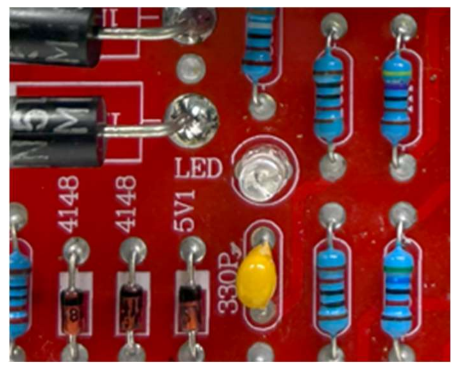


Remove the 24v voltage regulator from the main board taking care not to damage the PCB pads. I found it easier to use a pair of fine wire cutters and cut the regulator leads off just above the PCB (effectively rendering to 7824 unserviceable), leaving enough of the leg protruding to hold with a pair of needle lose pliers and gently pulling the leg from the PCB after applying sufficient heat to fully melt the solder joint.

☐ Fit a three pin header

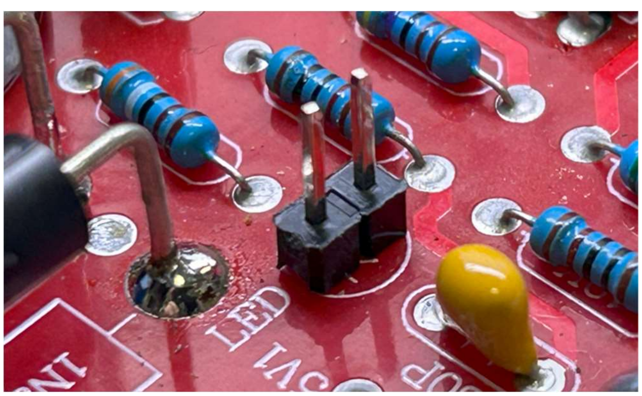
Break off and solder a three-header pin connector to the main PCB to enable soldering of the fly wires to connect to the regulator legs once the regulator is mounted on the heatsink. As with the pass transistor you may choose to solder some short lengths of hookup wire (24AWG in this case) directly to the PCB to enable connection to the voltage regulator once mounted on the heatsink, but I found it easier to solder the hookup wire directly to the voltage regulator and then to the pin headers when wiring up the rear panel (Step 6 – p20).

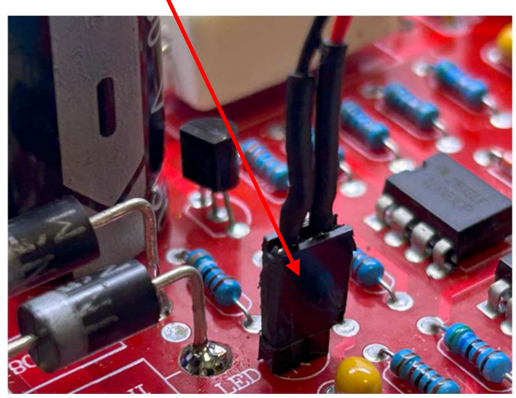
☐ Remove LED to facilitate remote mounting on the front panel



Identify and desolder the current limit LED indicator on the main board. The LED supplied with the board is a very bright blue LED which is difficult to dim to a comfortable level when on the front panel (although it does get your attention). You may wish to use the blue LED that you desoldered or a new LED supplied in the component kit, but we have also supplied a red LED in the Cowtown kit which is easier to dim and easier on the eyes.

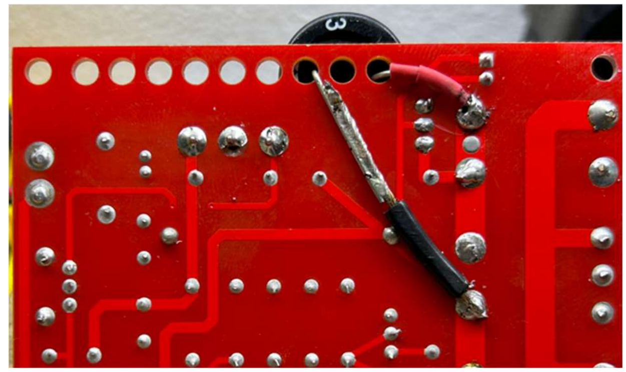
Again, you can choose to solder two lengths of hookup wire to the LED pads on the PCB and then connect these to the LED outputs on the voltage control board. I chose to build a 2 wire lead and plug from the voltage control board which is then connected to the main PCB using pin headers as shown on the photographs below. Pin headers are supplied with the Cowtown kit to build these connectors.





☐ **Optional** - Inclusion of a second capacitor

In the prototype that I built for the project and in some of the photographs used in this construction manual you will see a second 3300uF capacitor installed on the main PCB. I did this to provide additional smoothing of the DC output in situations where the load being applied lowered the input AC voltage from an underpowered AC transformer. The reality is that this lifted the output current by about 150mA before any output ripple was noticed under heavy load – the use of a suitably powered AC transformer will overcome this situation therefore **the installation of the second capacitor is optional and NOT a required component**. When installed, this capacitor makes wiring connections to voltage regulator and pass transistor on the heatsink more difficult, so unless you need this additional 150mA lift from an underpowered AC supply I recommend that you do not install a second 3300uF capacitor (from the component kit). For those who wish to do so the capacitor is soldered in parallel to the main PCB's 3300uF capacitor using pads on the underside of the PCB as shown below: Use heat shrink tubing to avoid any possibility of shorting to other components.

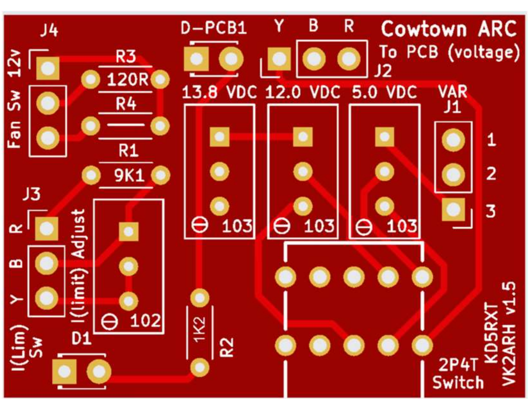


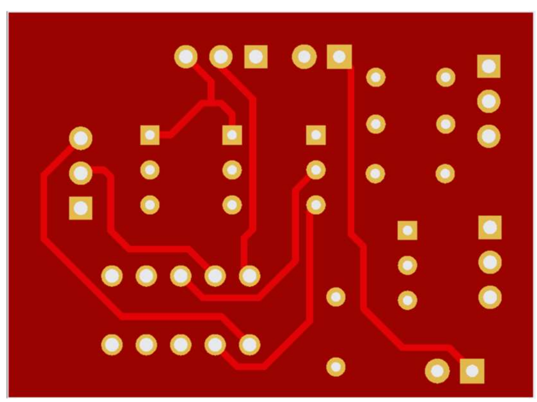
Step 2: Build the voltage and current limit control board

To simplify the wiring required for the voltage selection and current limit calibration, a small PCB was developed for use in the project. The board also supports the CC LED and fan speed controls.

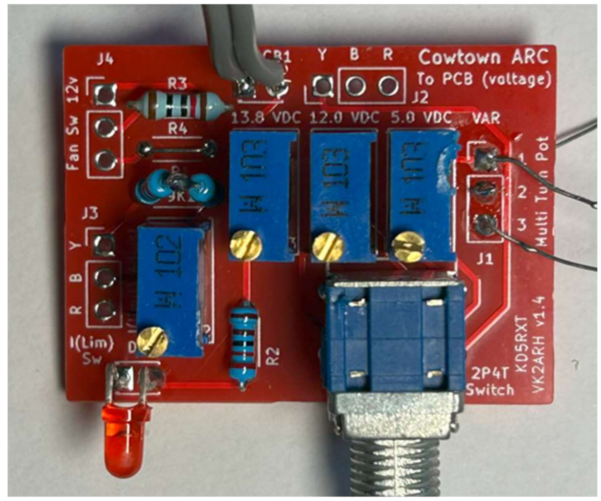
The images of the two sided board below are those supplied with the Cowtown kit and incorporate a few minor changes from the v1.4 shown in the construction photographs. Follow the screen print on the PCB and the hook up diagram in this manual as a guide for connections.

The most noticeable difference between version 1.4 (shown in the construction photographs) and version 1.5 (shown below) is the reversing of the Y and R identifiers on J3 connection, and rotating J1 through 180° whilst retaining the voltage adjust potentiometer connections 1,2,3 on the screen print in the same location.





It is easier to solder the board by starting with the smaller components first, the larger components and then the connecting hookup wires.



Identify and solder the following components to the PCB in this order:

- ☐ R1 - 9K1 1/4w resistor (used for constant current)
- ☐ R2 - 1K2 1/4w resistor (adjusts LED brightness)
- ☐ R3 - 120R 1/2w resistor (used for rear slow fan speed)
- ☐ R4 - 22R 1/2w resistor (used for internal slow fan speed)

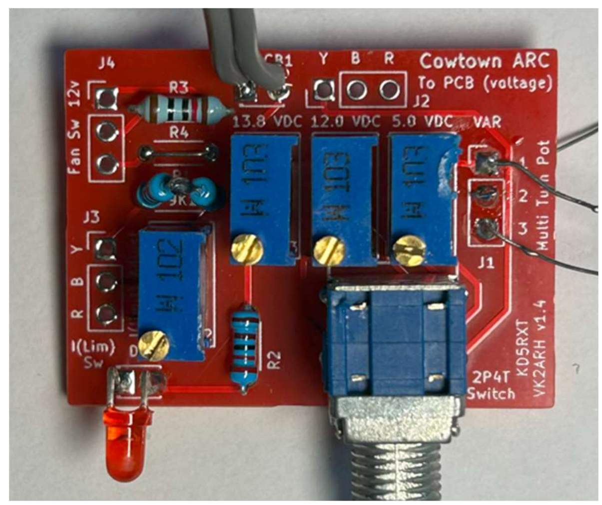
Notes:

R1 in the photo is shown as two resistors (as I didn't have a 9K1 resistor at hand) however the Cowtown kit is supplied with a single 9K1 resistor.

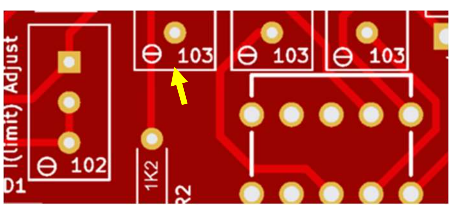
R3 and R4 may need to be mounted vertically polarized if the 1/2w resistor will not fit in the allocated space. Should you wish to adjust the slow speed setting for the fans, you can adjust the value of these resistors to suit your preference – the values selected and included in the kit provided a good balance between noise and sufficient air volume in the prototype supply. **R3** controls the slow fan speed of the heatsink fan whilst **R4** controls the slow fan speed of the internal fan.

Identify and solder the following components to the PCB:

- ☐ 3 x 103 (10K) Multi turn variable resistors
- ☐ 1 x 102 (1K) Multi turn variable resistor
- ☐ 2P4T rotary switch



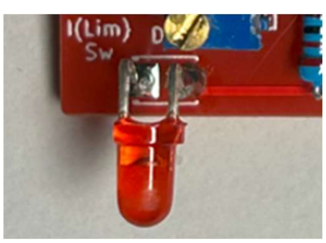
The orientation of the adjustment screws on the resistors is shown on the PCB screen print together with the value:

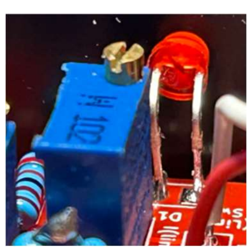


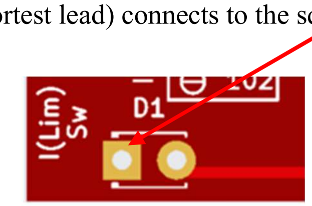
When soldering the rotary switch ensure that it is pressed down and flush with the PCB.

- ☐ D1 - Red LED

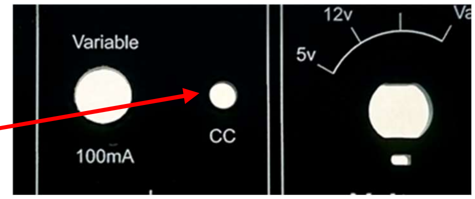
Ensure the correct polarity when installing the LED – the cathode (shortest lead) connects to the square solder pad.





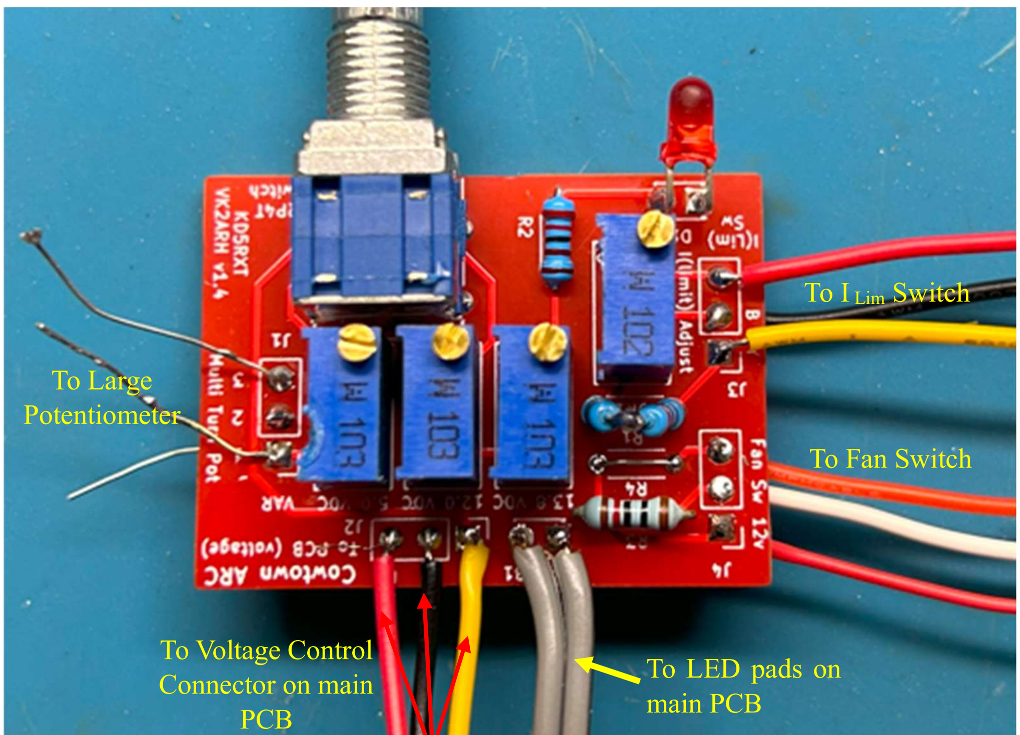


The diode is mounted proud of the PCB so that it can be folded forward and inserted into the CC hole on the front panel. With a pair of long nose pliers, bend the LED forward so that the base of the LED is approx. parallel with the edge of the PCB. Trial fit the PCB to the front panel by inserting the rotary switch with the PCB attached and aligning the height of the LED with the CC indicator hole on the front panel hole. When in position bent the protruding LED 'legs' to identify the required height of the LED above the PCB, remove and solder in place.



☐ Attach the hookup wire to the small PCB

It is easier to attach the hookup wire to the voltage control PCB at this stage. Cut off small lengths of 24 AWG wire and attach to the board as shown below. The colour of the wire is not important but using separate colours aids in ensuring correct wiring. I found it easier to use cut off resistor leads to connect the PCB to the large variable resistor using connection on the top and bottom of the board to avoid any possibility of the leads shorting against each other.

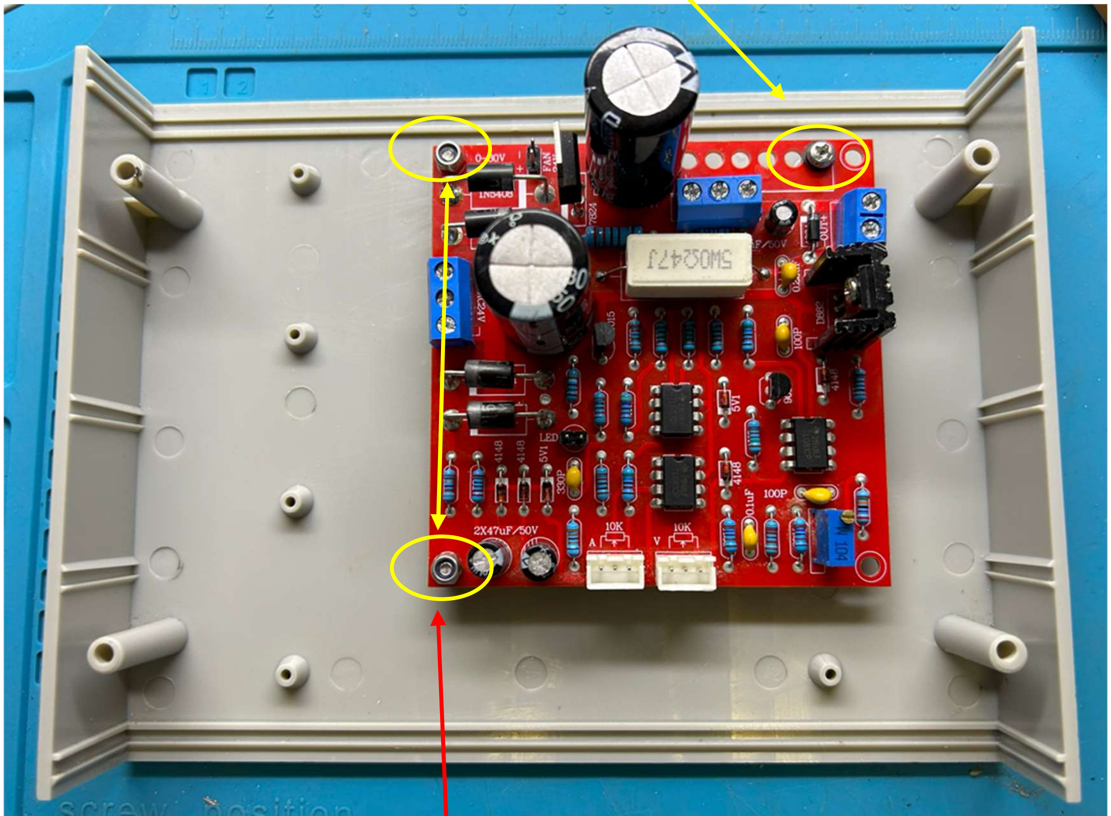


Note: The Red, Black, Yellow wire attached to the 3 pin connectors for the voltage and current limit controls supplied with the kit will need to be trimmed to length to allow a neat fit between the control board (and switch for the I $_{Lim}$ control). This wire is very thin once stripped of its outer insulation, and easily breaks at the solder joint with movement.

Solder these wires last and minimize their movement during installation. Once installed they are fine.

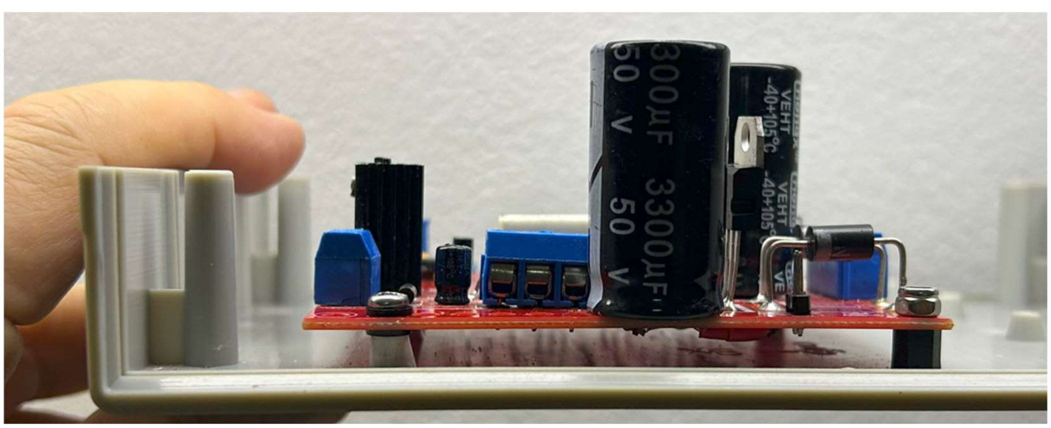
Step 3: Mount the main PCB in the enclosure

Mount the main PCB in the enclosure using one of the affixing points on the bottom of the case with the 8mm M3 machine screw. You may need to insert a couple of washers to hold it down. (Note these pictures are shown as an aid to fitting the PCB but show the prototype with the second 3300uF capacitor which is not used in the production version.)



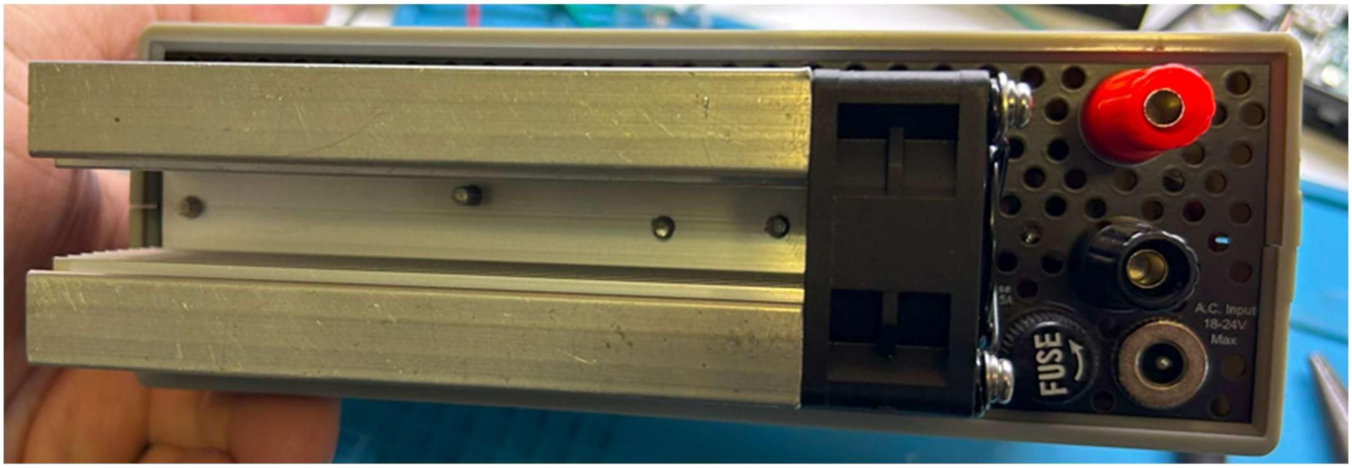
Whilst you may choose to secure the PCB with three further mounting points (and sufficient hardware is supplied in the kit to do this), I found securing only two more points was sufficient as shown above. To do this mark and drill 3mm (or 1/8") holes through the enclosure and insert 20mm M3 machine screw though the enclosure and a 6mm plastic standoff, then through the PCB securing down with an M3 Nyloc nut.

In this way the PCB is mounted and stands off from the bottom of the enclosure:

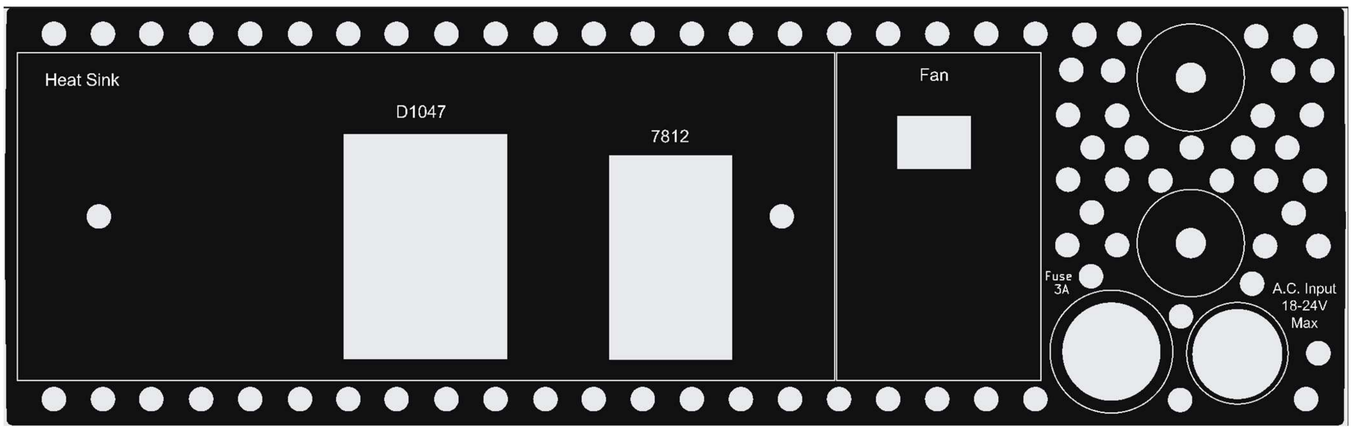


Step 4: Assemble the components on the rear panel

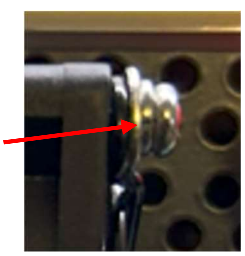
Now assemble the components to be mounted on the rear panel. The rear panel looks like this from the outside:



The panel holes are aligned to support mounting of the components:

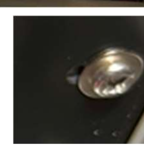


Steps to follow:



- ☐ Mount the cooling fan to the heatsink using 4 x 30mm M3 machine screws – these screws hold the fan guard against the fan. Use a washer and split washer between the fan guard and the machine screw head to ensure that the machine screw does not vibrate loose. The fan supply cables and connector are passed through the regtangular hole on the rear panel.

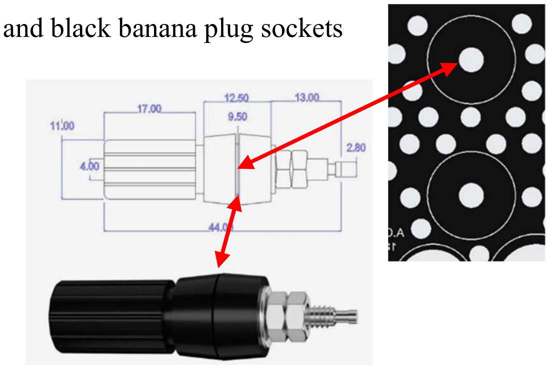
- ☐ Mount the fuse holder and the AC input socket to the panel using the hardware supplied with these components.



- ☐ Mount the heatsink and fan to the rear panel using two 20mm M3 machine screws and washer, which should be secured into the M3 threaded hole in the heatsink. Don't overtighten the screw otherwise you will strip the threat from the Aluminum heatsink – if you do you can drill an M3 hole though the heatsink and secure the heatsink to the panel using the 20mm M3 machine screws and an M3 nut, washer and split washer.

☐ If you wish to install the rear power outlet sockets, install the red and black banana plug sockets using the holes provide:

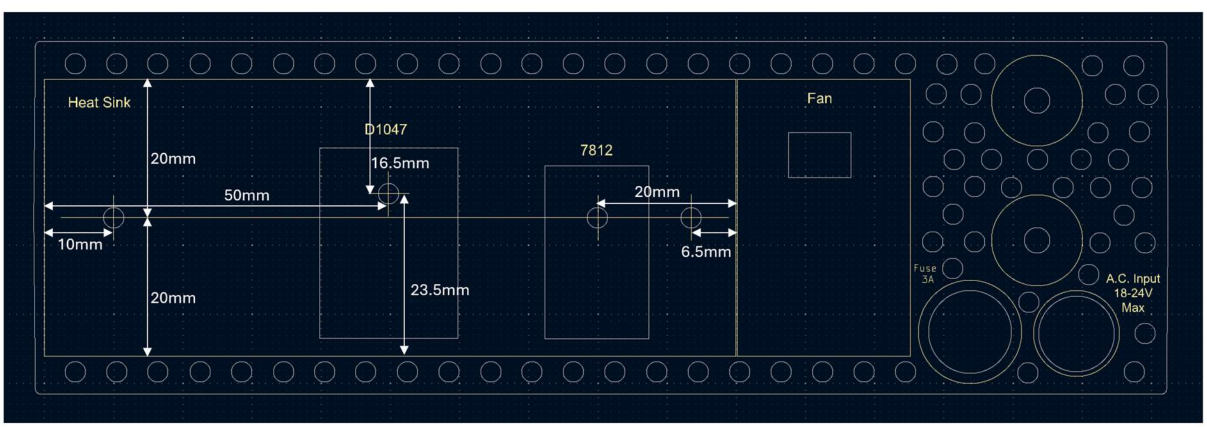
Note: unlike the mounting technique used on the front panel, the rear banana sockets are mounted using the smaller holes provided to ensure that the maximum amount of panel was available for a secure mounting point and one not weakened by the number of air vent holes. Disassemble the banana socket and pinch the panel insulators between the PCB as shown:



☐ Mount the heatsink and fan to the rear panel using two 20mm M3 machine screws and washer, which should be secured into the M3 threaded hole in the heatsink. Don't overtighten the screw otherwise you will strip the thread from the Aluminum heatsink – if you do you can drill an M3 hole though the heatsink and secure the heatsink to the panel using the 20mm M3 machine screws and an M3, Nut, Washer and Split washer.

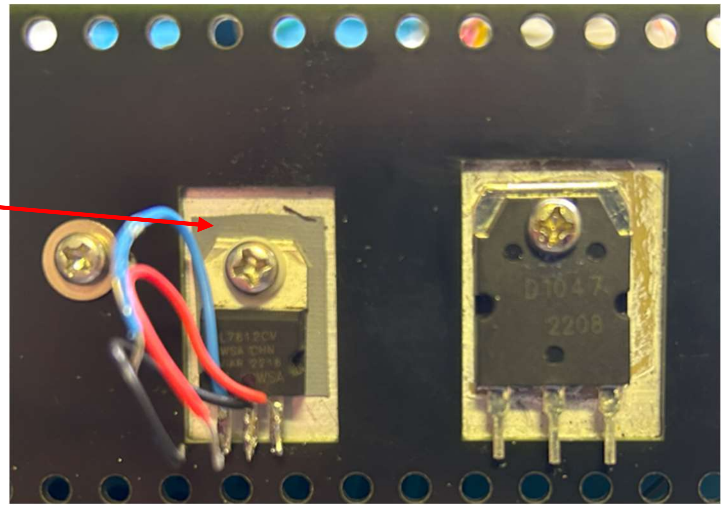
The finished product should look something like this:

In the Cowtown kit the heatsink was pre-drilled – a huge vote of thanks to Dan Pate AI5OL for doing this. For those who need to drill their own heatsink, the drill guide is shown below:



Heat Sink is 40mm x 100mm
Outline shown on back panel
Position of 4 holes to be tapped to M3 shown above
Thread is M3 x 0.5 pitch

☐ Attach the D1047 pass transistor and the 7812-voltage regulator to the heatsink using 2 x 20mm M3 screws, silicon insulating pads and the insulating washer on the 7812. (Note: in the prototype I used a mica washer for the D1047, but the kit is supplied with a silicon pad.



Both components are secured to the heatsink with a 20mm M3 screw. If the heatsink has been ‘tapped’ screw into the tap and tighten after fitting a silicon insulating pad between the device and the heatsink. Take care when tightening the screws not to strip the thread from the aluminum heatsink.

If the heatsink has not been ‘tapped’ you will need to affix the device with the M3 screw, a split washer and nut.

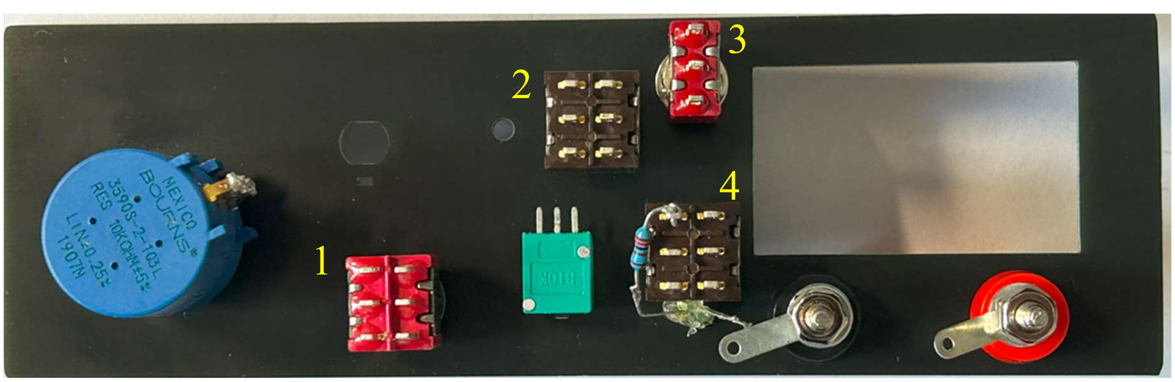
With the Voltage regulator you will need to insert an insulating washer with the M3 screw to insulate the 7812 from the heatsink. This is not required for the D1047 as the rear of the transistor has an insulating ring around the attachment hole.

Solder three flyleads to the 7812 legs after shortening them, to enable connection to the main PCB. It is easier to attach the flyleads at this point than later in the build.

Step 5: Assemble the front panel and wiring between the components

☐ Affix the components to the front panel in the positions shown below. Do NOT install the digital display at this stage. Also note the inclusion of the solder lugs on the rear of the banana sockets.

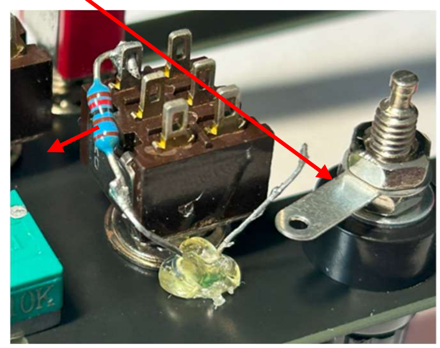
When tightening the nuts on the components take care not to scratch the screen print on the front of the panel. Take it slowly and carefully. I found it best to use small spanners for tightening the nuts, and if installing a locking washer or washer place it on the back of the panel for all the switches and the front of the panel for the potentiometers as the knob will cover the washer.



The colour of the supplied switches in the kit may vary from those shown above but the key to the switch locations is shown below:

1. DPTT: ON-OFF-ON For fan speed control
2. DPDT: ON – ON for Current limit selection
3. SPDT: ON - ON for main power switch (connects AC input to the PCB)
4. DPDT: ON – ON for the load switch (connects power supply output to the output sockets)

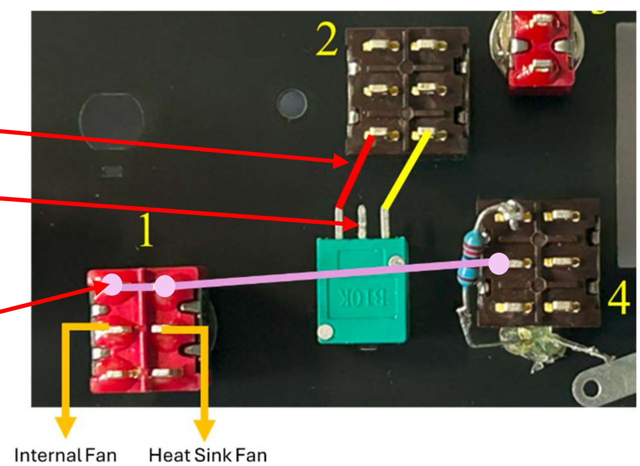
When installing the banana sockets the panel insulators have a protruding shroud which holds the socket in place, and this should be affixed to the outside of the panel. These are designed to support use on a sheet metal panel and provide insulation for the center conductor which passes through the panel. Attach solder lugs to the back of each banana socket for soldering connections to the socket.



- ☐ Mount the Load ON - LED (green LED) to the load switch as shown here using a current limiting 1K2 ¼ watt resistor. Take care to ensure that the leads of the resistor does not short against the body of the switch – **use heat sink tubing** (not used in the photograph) or extend the resistor to the left hand side further than shown in the photo to ensure that this does not occur. Whilst not essential – if you have a 'dob' of glue gun 'goo' – this helps keep the LED in place although the leads when soldered also hold the LED in place.

  Observe the correct polarity of the LED – **the Cathode (shorter lead) connects to the -ve solder lug on the banana socket.**

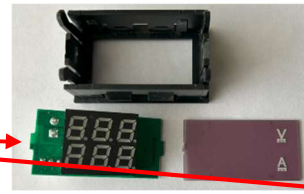
Make the following solder connections to the front panel before any further component installation as it is easier at this stage:

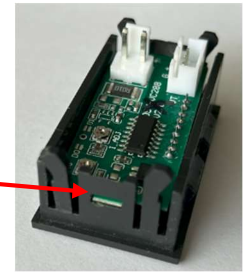


- ☐ Connect the 10K potentiometer for CC control to the lower two lugs of the DPDT switch using 24AWG hookup wire as shown:
- ☐ Bend the center lead on the potentiometer inward as this will be used to connect the black wire from the voltage control board to the black wire leading to the Current limit control.
- ☐ Connect the center lug of the DPDT Load ON switch to the **top two lugs** of the DPTT ON-OFF-ON switch used for fan control as shown:
- ☐ Connect two fly leads of hookup wire to the middle lugs of the DPTT ON-OFF-ON switch used for fan control as shown:

The colour of the wire is not important but colours are used here as a guide to assist in identification of the wiring. NOTE: the wiring to the potentiometers and from the front control board refers to red, black and yellow wires to align with the wire colours used in the PCB connectors supplied with the kit.

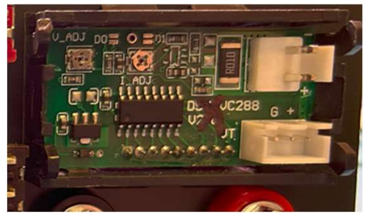
- Fit the digital display to the front panel. In order to do this, you first need to separate the display shroud from its components by prying the PCB from the shroud where it is held in with a small tab.





- Then insert the shroud into the front panel. The absence of the internal PCB facilitates compression of the shroud as it is inserted through the hole in the PCB.

- The display components can then be fitted back into the mounting shroud from the rear:



Install the voltage control board onto the front panel, carefully aligning the LED to the CC LED hole on the front panel.

Once secure, wire the connections from the voltage control board to the components as shown on the following diagram (top of page 21). This diagram will be used for both the front and rear panel connections as well as the connections to the main PCB.

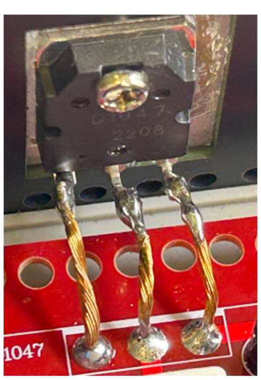
It is easier to wire the voltage control PCB connections to the front panel components before wiring up connections to the rear panel and the main PCB.

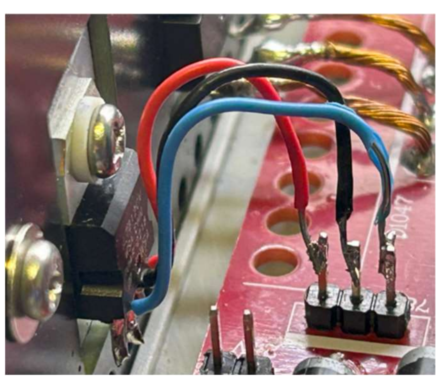
Step 6: Wire up the front and rear panels to the main PCB

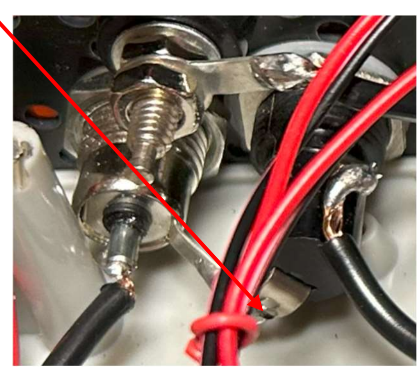
After fitting the 'fly wires' to the front and rear panels, use additional appropriately sized wire to connect the components on the panels to the main PCB. The wiring diagram for these connections is shown on the following page. There is no specific colour code required for the wiring, but keeping separate colours for the connections makes tracing and soldering the wires to the correct connection easier.

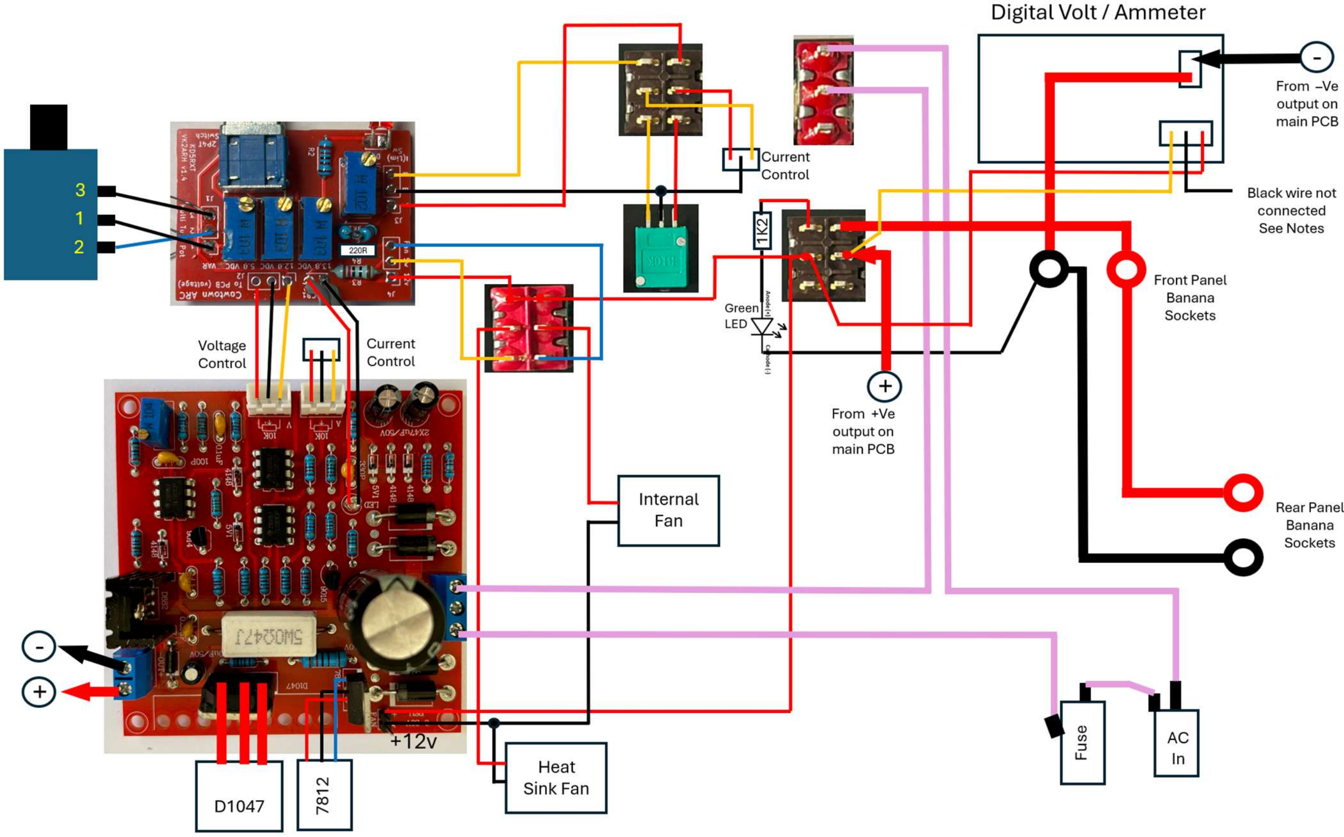
For the main DC output and AC input use at least 18 AWG wire. For the remaining connections 24AWG wire is fine.

The following photos show one possible way of wiring the D1047 and 7812 to the main board, and the photo on the right shows the Fuse and 'AC IN' sockets lugs bent and soldered together without the need for a connecting wire.



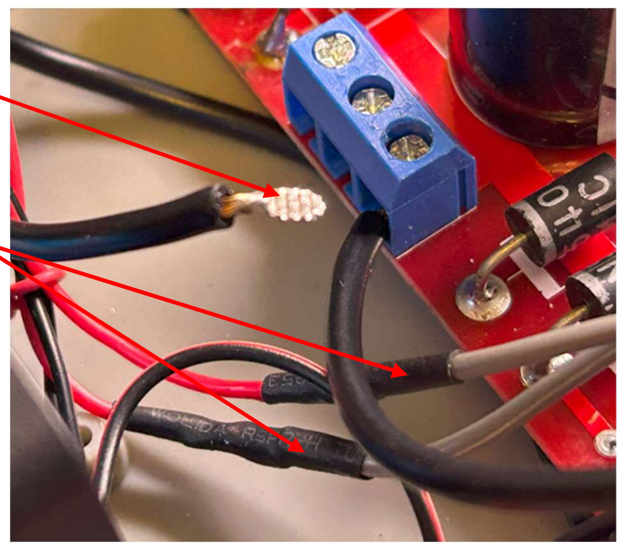






A larger version of this diagram can be found on the page 29 of this manual

- I found it easier to connect the 18AWG wire to the screw terminals for the AC IN and DC out after tinning the end of the wire, then compressing it with a pair of pliers, trimming it if required, to form a lug that was inserted into the screw terminal.
- Good practice is to use heat shrink tubing to cover joints in the hookup wire.
- The small black wire from the voltage in connector on the digital display is NOT connected as this provides the highest accuracy of the current meter display, by avoiding return loops which seem to impact the accuracty of the ammeter.



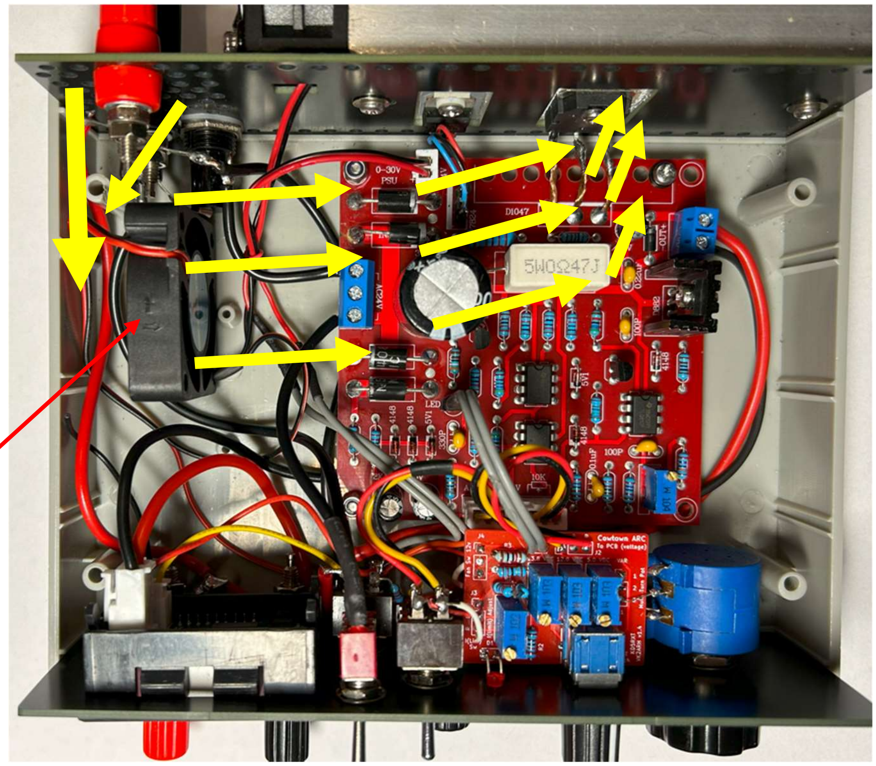
Step 7: Mounting the Internal Cooling Fan

It is easier to mount the internal cooling fan as the last item to be installed.

I secured the fan to the enclosure with a strip of heavy duty permanent double-sided tape on the fan base and this has worked well. You may wish to experiment with other types of fixtures.

The fan position is shown here:

The airflow path that is generated by the fan is shown in yellow. The air is drawn in through the large number of holes around the rear connectors and exits through the row of holes above and below the heatsink.

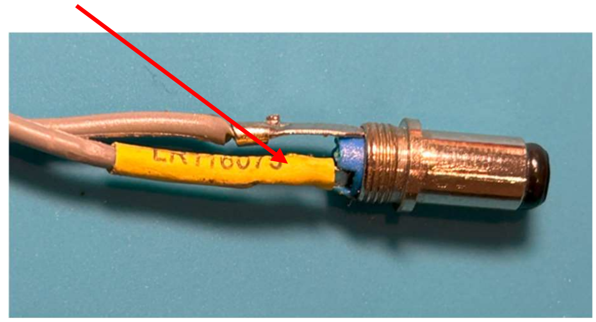


Step 8: Prepare your external AC power supply

The power supply requires an external AC input voltage in the range of 18-24v Max. For most amateur radio purposes, the selection of an 18v AC input source will be the best option. **The input voltage should NOT EXCEED 24v AC.**

The power output capability of the AC supply should be approx. 30% higher than the desired output current from the power supply as the transformer will reduce its voltage as you approach its maximum output current. The impact will be an inability to maintain a stable 13.8v output from the supply under heavy load if the input transformer cannot supply 18VAC at the required current, although output at lower voltages may be unaffected.

- ☐ Connect the 5.5 x 2.1mm DC plug to the external AC transformer supply lead (polarity is not important). When soldering the connector use heatsink tubing to insulate the two AC wires.
- ☐ Install the 3A fuse into the fuse holder.



<u>Note</u>: although the power supply is shown as a 2.5A Max supply, it is actually rated at 3A so there is some headroom associated with its use. For this reason and to supply additional power for the cooling fans and digital display a 3A fuse was chosen for the project. You should now be able to power up and check the operation of your power supply.

Step 9: Test and Calibrate the supply

There are four calibrations required to get the best out of the supply:

1. Voltage Display
2. Preset Voltage Levels
3. Current Display
4. Constant Current 100mA level

Note: The digital display can be adjusted to be very accurate, but the accuracy is not linear across the entire range – therefore I recommend adjusting the accuracy of the display for the voltage / current setting that is going to be most frequently used – each end use case will vary, but I suggest that targeting the 12-13.8v range and 200 - 500mA outputs will be a good point to start.

The Digital display has two adjustment potentiometers mounted on its PCB. These provide a small adjustment range and are quite sensitive so adjustments should be made carefully and slowly.

Voltage Adjustment

Current Adjustment

☐ Connect the AC power source to your power supply and switch the main power switch on – you should see your digital display illuminate with a voltage reading but no current reading at this stage. With the voltage select dial set to 'Variable' rotate the main voltage adjust knob and you should see the voltage display change. If this is not the case start fault finding and check your wiring.

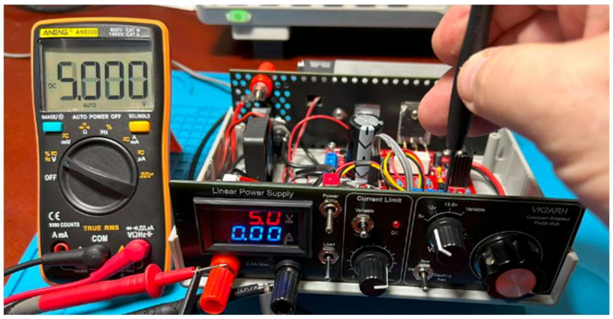
☐ **Voltage Display Calibration**

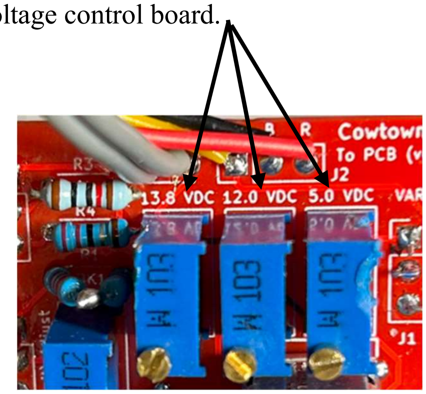
- Connect a voltmeter as your calibration reference to the power supply.
- Set the voltage selections switch on the front panel to 'Variable' and adjust the main voltage adjust potentiometer so that your multimeter reads 12v.
    - Note: there is approximately a 1 second time lag on the digital display as it calculates and builds the output display. This can be a little frustrating, but you get used to it – your multimeter will likely respond quicker.

- Using a small (tiny) screwdriver adjust the voltage potentiometer at the back of the digital display so that the display aligns with the multimeter.
- You can now check the voltmeter accuracy for other voltage ranges rotating the voltage adjust potentiometer. Make sure that the current limit potentiometer is turned to maximum for this calibration.

☐ **Preset Voltage Level Calibration**

- Turn the Voltage Selection switch on the front panel to 13.8v and adjust the 13.8v adjust potentiometer on the voltage control board so that your multimeter (or front panel) reads 13.8v
- Repeat the process for the 12v and 5v voltage selector setting adjusting the associated voltage adjustment potentiometer which is identified by the silkscreen on the voltage control board.



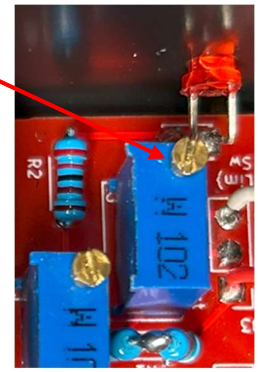


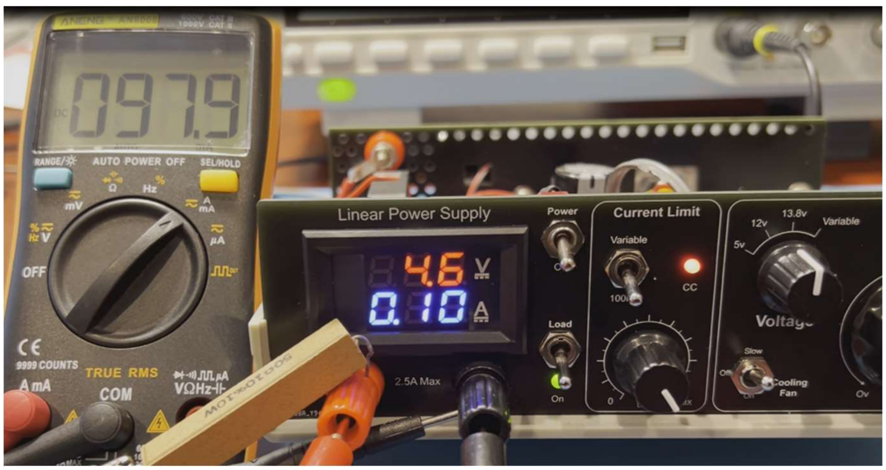
☐ **Current Display Adjustment**

- Turn the current limit switch to variable and turn the I $_{\mathrm{Lim}}$ potentiometer fully clockwise to the maximum position.
- Connect a load to the power supply which will draw your reference current. (I used a 10w 10% 50 Ohm resistor – actually measured out at 47.7 Ohm which drew ~288mA at 13.8v).
- Wire your reference ammeter in series with the load. Adjust the current adjustment potentiometer at the rear of the display so that it aligns with the multimeter.

☐ **Constant Current 100mA Adjustment**

- Connect a load which generates an output more than 100mA to your supply, together with a reference ammeter in series.
- Turn the CC switch on the front panel to 100mA, and the voltage selection switch to 'Variable'
- Adjust the voltage output so that the load draws 100mA as shown on your reference ammeter. (97.9mA is close enough 😌)
- Adjust the I_{Lim} potentiometer to the point where the cc light illuminates.

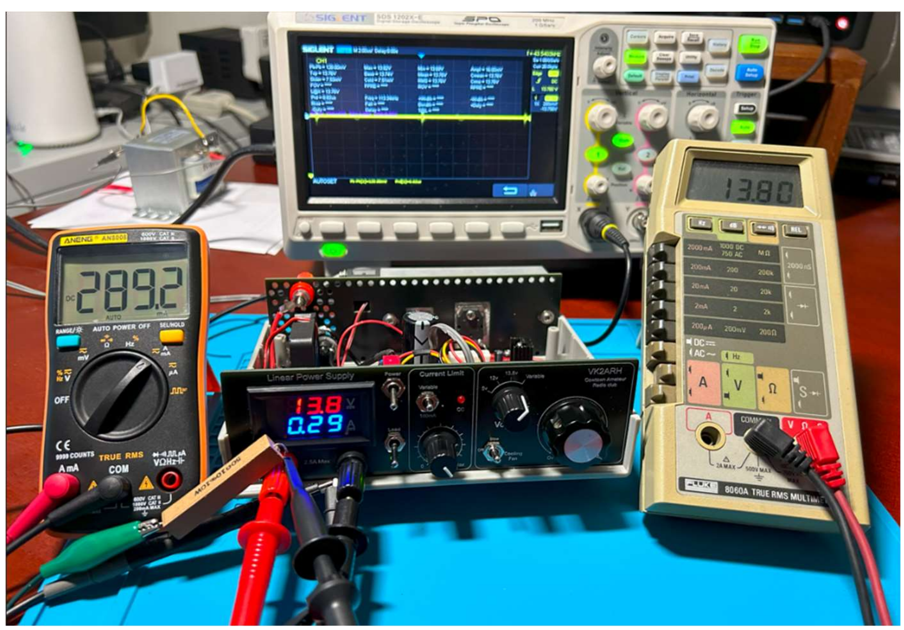




- Your current limit is now set to 100mA.
  - You can check this by switching the Current Limit switch back to variable – increasing the voltage applied to the load and witnessing the increase in current.
  - Now switch the current limit switch to 100mA and your output voltage should drop and present a 100mA output current.

Your power supply should now be calibrated – assemble the enclosure using screws supplied with the enclosure which also hold the plastic feet in place

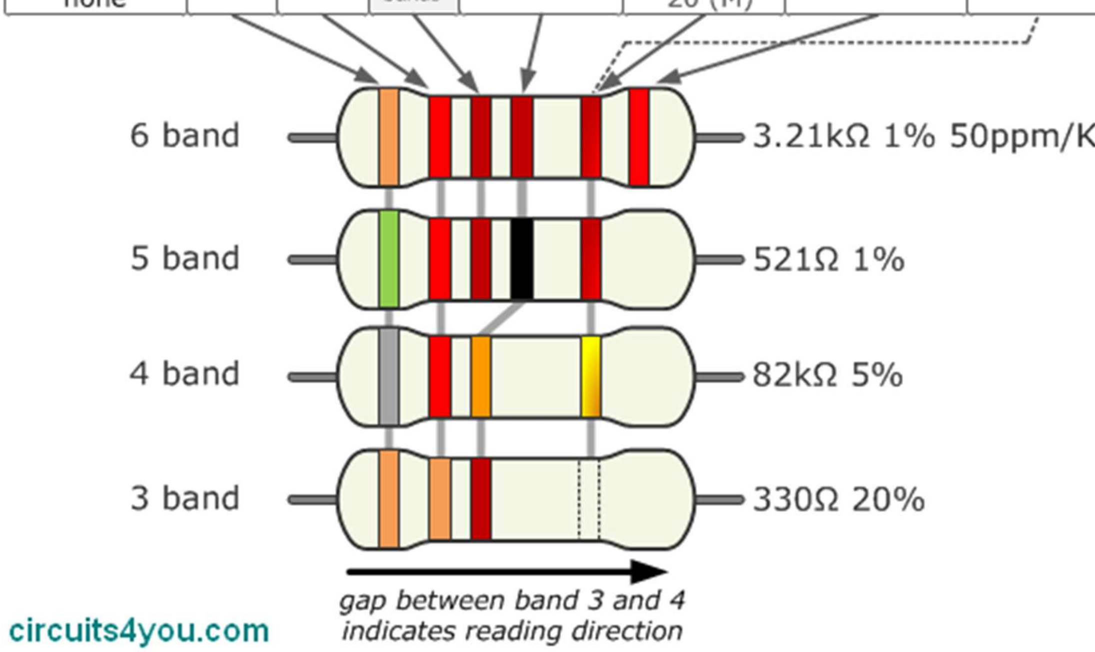
Enjoy your build 😌



Useful Information

Resistor Color Code Chart

Color	Signficant figures			Multiply	Tolerance (%)	Temp. Coeff. (ppm/K)	Fail Rate (%)
black	0	0	0	x 1		250 (U)	
brown	1	1	1	x 10	1 (F)	100 (S)	1
red	2	2	2	x 100	2 (G)	50 (R)	0.1
orange	3	3	3	x 1K		15 (P)	0.01
yellow	4	4	4	x 10K		25 (Q)	0.001
green	5	5	5	x 100K	0.5 (D)	20 (Z)	
blue	6	6	6	x 1M	0.25 (C)	10 (Z)	
violet	7	7	7	x 10M	0.1 (B)	5 (M)	
grey	8	8	8	x 100M	0.05 (A)	1(K)	
white	9	9	9	x 1G			
gold			3th digit only for 5 and 6 bands	x 0.1	5 (J)		
silver				x 0.01	10 (K)		
none					20 (M)		



Power Supply Board Kit – Assembly Instruction

EQKIT

Precautions before power on:

1. Only input AC (15--24V), and the maximum can not exceed 24V。 2. Please make sure that the cooling fin is insulated from the circuit when it is installed on Q4(D1047). The circuit is of a linear stabilized electricity power, and the power dissipation of Q4 is at a relatively high level, thus please ensure that D1047 has a good cooling effect.

Circuit debugging:

1. Voltage Conditioning

Turn potentiometer P1 to the minimum, and then adjust the RV1 potentiometer, Make the output voltage is 0V.

2. Current Conditioning

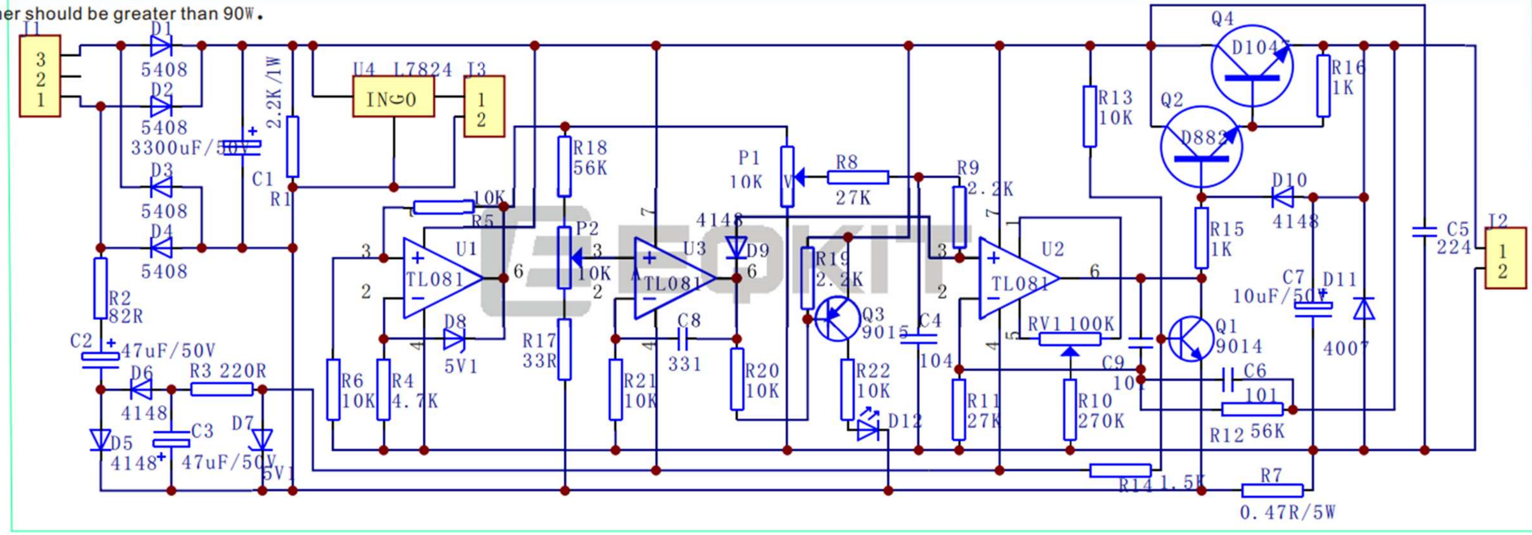
Connect the load resistance to the output point,for example,10Ω(make sure there is enough power), and the current potentiometer set at its max and the voltage potentiometer at its min,turn on the device,build up the voltage to 1V slowly,rotate the current potentiometer counterclockwise till the LED begin to emit light,at which point the current of the circuit is limited at 0.1A and the position could be marked. Adjust to 2V,5V,10V,20V,30V successively,and you could calibrate different input current,the formula is:I=U/R. For example,if the load of 10Ω is used,and U at 30V,I=3A (max output).You could substitute other load resistance with different values,but please make sure there is enough power and cooling.

Component list

Name	Type	Num	Qty
Res	2.2K/1W	R1	1
	82Ω	R2	1
	220Ω	R3	1
	4.7K	R4	1
	10K	R5 R6 R13 R20 R21 R22	6
	0.47Ω/5W	R7	1
	27K	R8 R11	2
	2.2K	R9 R19	2
	270K	R10	1
	56K	R12 R18	2
	1.5K	R14	1
	1K	R15 R16	2
	33Ω	R17	1
Pot	100K (3296W)	RV1	1
	10K	P1 P2	2
E.cap	3300UF/50V	C1	1
	47UF/50V	C2 C3	2
	10UF/50V	C7	1
MLCC	104P	C4	1
	224P	C5	1
	101P	C6 C9	2

MLCC	331P	C8	1
Diode	1N5408	D1 D2 D3 D4	4
	1N4148	D5 D6 D9 D10	4
	1N4007	D11	1
LED	3mm Red	D12	1
Z.diode	5V1	D7 D8	2
Triode	S9014	Q1	1
	2SD882	Q2	1
	S9015	Q3	1
	2SD1047	Q4	1
Chip	TL081	U1 U2 U3	3
	L7824	U4	1
C.termin	KF301-3P	J1	1
	KF301-2P	J2	1
	XH2.54 2P	J3	1
	XH2.54 3P	P1 P2	2
PCB	94.2*80mm	FR4 Thickness 1.2mm	1
Cable	3P Cable	L=300mm	1
C. fin	TO-220	Q2 Dissipate heat	1
Screw	M3*6	Fixed Q2	1
	M3*22	Fixed Q4	1
Nut	M7	Fixed P1 and P2	2

Attentions:The output of the transformer is single 24V or dual 12V(same as 24V),and the power could be determined according to your need. If a full load output (30V 3A) is needed,the power of the transformer should be greater than 90W.



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Power Supply Wiring ‘Hook Up’ Diagram

Wire colour is not critical but shown for illustration purposes.